Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

May 2019

Chemistry

Standard level

Paper 3

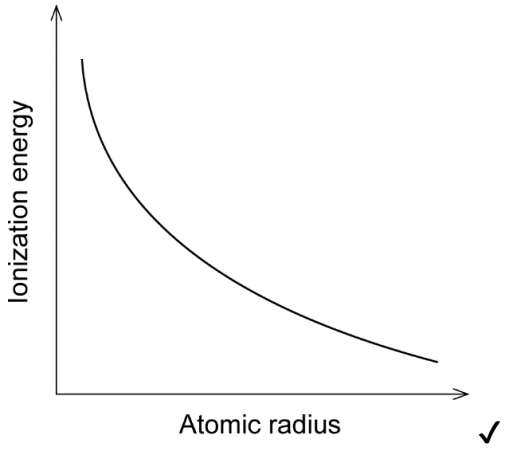
24 pages

Section A

Question			Answers	Notes	Total
1.	a		group 18/noble gases ✓ smallest difference between melting and boiling points ***OR*** weakest intermolecular forces «in that period» ✓	*Accept "group 17/halogens".*	**2**
1.	b	i	density increases «to a maximum in the transition elements» ***AND*** then decreases ✓		**1**
1.	b	ii	actinoids ***AND*** density increases down all groups «due to large increase in atomic mass for small increase in atomic volume» ***OR*** actinoids ***AND*** «much» greater atomic mass with similar type of bonding ***OR*** actinoids ***AND*** density «of actinoids» atomic number 90 to 95 is greater than corresponding lanthanoids ✓	*Accept "actinoids **AND** on graph actinoids have «much» greater density than lanthanoids".*	**1**

(continued…)

(Question 1b continued)

Question			Answers	Notes	Total
1.	b	iii	***Alternative 1:*** **«**metals with**»** low densities oxidize easier ✓ **«**metals with**»** low melting points oxidize easier ✓ ***Alternative 2:*** in s-block **«**metals with**»** high densities oxidize easier ***OR*** in s-block **«**metals with**»** low melting points oxidize easier ✓ in d-block **«**metals with**»** low densities oxidize easier ***OR*** in d-block **«**metals with**»** low melting points oxidize easier ✓	*Award **[1 max]** for "s-block metals more easily oxidized" **OR** "s-block metals have lower melting points" **OR** "s-block metals have lower densities".* *Accept "have greater activity" for "oxidize easier".*	**2**
1.	b	iv	 ✓	*Accept any negative sloping line.* *Do **not** award mark if line touches either axis.*	**1**

Question			Answers	Notes	Total
2.	**a**	**i**	100 **«s»** ✓	*Accept 90 to 100 s.*	**1**
2.	**a**	**ii**	highest recorded temperature ***OR*** when rate of heat production equals rate of heat loss ✓	*Accept "maximum temperature".* *Accept "completion/end point of reaction".*	**1**
2.	**b**	i	*Maximum temperature:* 73 «°C» ✓ *Assumption:* «temperature reached if» reaction instantaneous ***OR*** «temperature reached if reaction occurred» without heat loss ✓	*Accept "rate of heat loss is constant" **OR** "rate of temperature decrease is constant".*	**2**
2.	**b**	**ii**	*Any one of:* copper(II) sulfate ***AND*** mass/amount of zinc is independent variable/being changed. ***OR*** copper(II) sulfate ***AND*** with zinc in excess there is no independent variable **«**as amount of copper(II) sulfate is fixed**»** ✓ copper(II) sulfate ***AND*** having excess zinc will not yield different results in each trial ✓ zinc ***AND*** results can be used to see if amount of zinc affects temperature rise «so this can be allowed for» ✓ zinc ***AND*** reduces variables/keeps the amount reacting constant ✓		**1 max**

(continued…)

(Question 2b continued)

<table>
<tr><th colspan="3">Question</th><th>Answers</th><th>Notes</th><th>Total</th></tr>
<tr><td>2.</td><td>b</td><td>iii</td><td>
<table>
<tr><th>Value</th><th>Assumption</th></tr>
<tr><td>$m = 25.00\,\text{g}$</td><td>density of solution is $1.000\,\text{g}\,\text{cm}^{-3}$/same as water
OR
$25.00\,\text{cm}^3$ solution has a mass of 25.00 g
OR
mass of zinc/reactant is negligible
OR
mass of contents was 25.00 g ✓</td></tr>
<tr><td>$c = 4.18\,\text{J}\,\text{g}^{-1}\,\text{K}^{-1}$</td><td>specific heat of solution is $4.18\,\text{J}\,\text{g}^{-1}\,\text{K}^{-1}$ /same as water
OR
zinc/calorimeter/beaker/thermometer absorbs no heat ✓</td></tr>
</table>
</td><td>Accept “copper(II) sulfate/zinc sulfate” for “solution”.</td><td>2</td></tr>
<tr><td>2.</td><td>b</td><td>iv</td><td>lower/less exothermic/less negative AND heat loss/some heat not accounted for
OR
lower/less exothermic/less negative AND mass of reaction mixture greater than 25.00 g
OR
greater/more exothermic /more negative AND specific heat of solution less than water ✓</td><td>Accept “temperature is lower” instead of “heat loss”.
Accept “similar to theoretical value AND heat losses have been compensated for”.
Accept “greater/more exothermic/more negative AND linear extrapolation overestimates heat loss”.</td><td>1</td></tr>
</table>

Section B

Option A — Materials

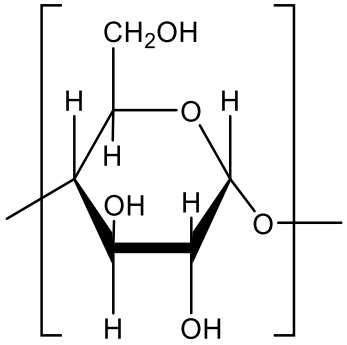
Question			Answers	Notes	Total
3.	**a**	**i**	ionic ✓		**1**
3.	**a**	**ii**	lithium has an unpaired electron ✓ all electrons in lithium hydride are paired ✓	*Award **[1 max]** for correct electron configurations of Li **AND** Li^+ **AND** H^- without discussion of pairing.*	**2**
3.	**b**	**i**	emission spectra of both «^{6}Li and natural Li» give same colour/produce same «range of» wavelengths ***OR*** they have same electron transitions/same nuclear charge ✓	*Accept "the spectra are almost identical".*	**1**
3.	**b**	**ii**	ICP-MS ✓	*Accept "MS/mass spectrometry".*	**1**
3.	**c**		$n = \frac{m}{M_r} = \frac{0.694}{6.94} = 0.100\ \text{mol}$ ✓ $t = \frac{0.100\ \text{mol} \times 96\,500\ \text{C mol}^{-1}}{2.00\ \text{C s}^{-1}} =$ 4830 «s» ✓	*Accept "4820" **OR** "4825 «s»".* *Award **[2]** for correct final answer.*	**2**

Question			Answers	Notes	Total
4.	**a**		*Any two of:* heterogeneous catalyst is in different phase than reactants ***AND*** homogeneous catalyst in same phase ✓ homogeneous catalysts chemically change/react and are reformed at end of reaction ***OR*** reactants adsorb onto heterogenous catalyst and products desorb ✓ heterogeneous catalysts are more easily removed than homogenous catalysts ✓ heterogeneous catalysts can function at higher temperatures ✓ homogeneous catalysts are **«**generally**»** more selective ✓ homogeneous catalysts offer a broader range of reactions ✓	*Accept "state" for "phase".* *Accept "heterogeneous catalyst provides a surface to activate reaction".*	**2 max**
4.	**b**		elastomers bend under force **«**and return to original form when force is released**»** ***OR*** elastomers make tyre more flexible ✓ allows greater contact with road ✓		**2**
4.	**c**	**i**	does not contain heterocyclic ring with 2 oxygen atoms ***OR*** middle ring has only 1 oxygen atom ✓ produces similar toxic effects to dioxins ✓	*Accept "does not contain dioxin ring" for M1.*	**2**
4.	**c**	**ii**	taken up by plants, which are eaten by animals **«**and then further dispersed**»** ***OR*** passed on in food chain ✓	*Accept "do not break down and can be remobilised as dust".*	**1**

Question			Answers	Notes	Total
5.	**a**		nitrile ✓	*Accept "cyano"*.	**1**
5.	**b**		*Low temperature:* intermolecular forces prevent molecules moving ***AND*** solid/**«**normal**»** crystal formation ✓ *High temperature:* **«**above a critical temperature**»** disrupts alignment of molecules ***AND*** behaves as fluid/liquid ✓	*Accept "weak intermolecular forces break **AND** behaves as fluid/liquid".*	**2**

Question			Answers	Notes	Total
6.	**a**		*Structure:* giant covalent/network covalent ✓ *Bonding:* each carbon covalently bonded to 3 other carbons ***OR*** each bond has order of 1.5	*Accept "cylindrical/tube shaped".* *Accept "has delocalized electrons"* ***OR*** *"has sp^2 hybridization".*	**2**
6.	**b**		*Any one of:* 3D electrodes ✓ catalysts ✓ biosensors ✓ molecular stents ✓ body armour ✓ synthetic muscles ✓ micro transistors/circuitry/capacitors/electrodes ✓ reinforcing phase in a matrix/composite material «such as concrete» ✓ micro antenna ✓ stealth technology ✓ water/air filtration ✓ solar cells ✓ tennis racquets ✓ microelectronic circuits ✓	*Do* ***not*** *accept just general answers such as "medicine" or "defence".*	**1 max**

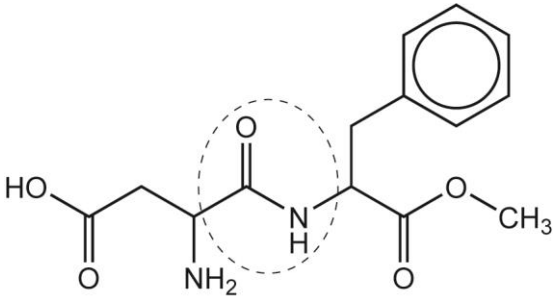
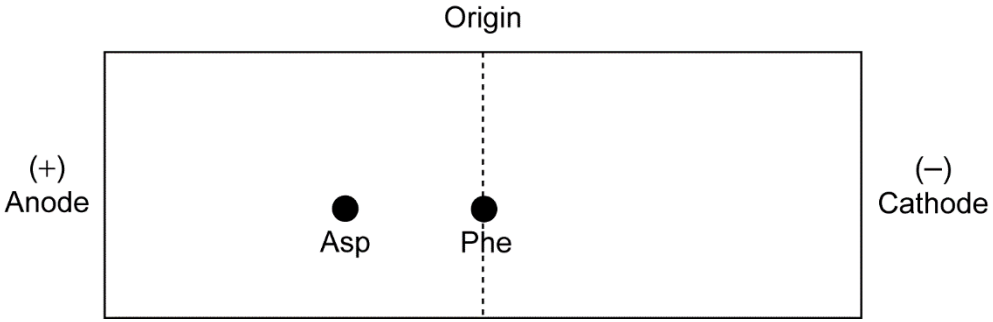
Option B — Biochemistry

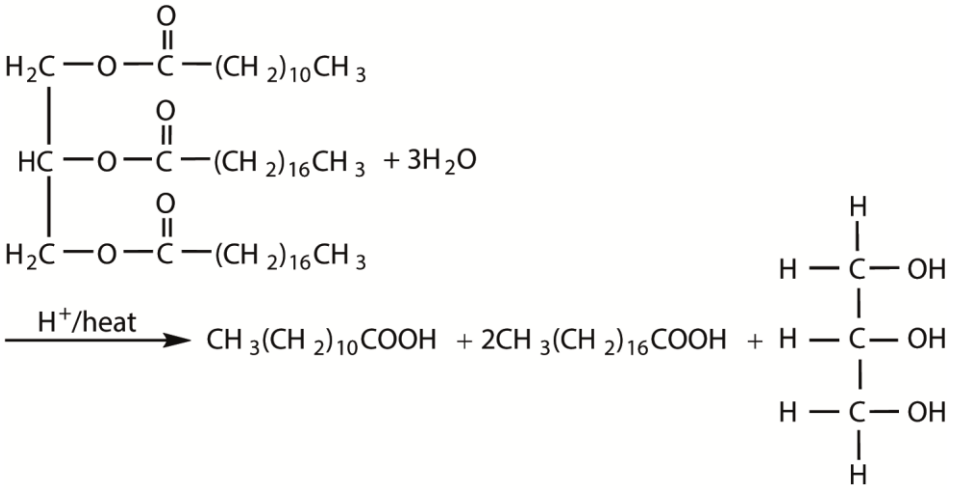
Question			Answers	Notes	Total
7.	**a**		 continuation bonds ***AND*** -O- attached to just one end **AND** both H-atoms on end carbons must be on the same side ✓ *Type of linkage:* glycosidic ✓	*Square brackets not required.* *Ignore "n" if given.* *Mark may be awarded if a polymer is shown but with the repeating unit clearly identified.* *Accept "ether".*	**2**
7.	**b**		$(C_6H_{10}O_5)_n\,(s) + nH_2O\,(l) \rightarrow nC_6H_{12}O_6\,(aq)$ ✓	*Accept "(n-1)H_2O".* *Do **not** award mark if "n" not included.*	**1**
7.	**c**		$q = mc\Delta T = 975\,g \times 4.18\,J\,g^{-1}\,K^{-1} \times 15.0\,K$ =» 61 100 «J» / 61.1 «kJ» ✓ «heat per gram= $\frac{61.1\,kJ}{3.49\,g}$ =» 17.5 «kJ g^{-1}» ✓	*Award **[2]** for correct final answer.*	**2**

(continued…)

(Question 7 continued)

Question			Answers	Notes	Total
7.	**d**		*Any two of:* carbohydrate grains swell/break plastic into smaller pieces ✓ inclusion of carbohydrate makes the plastic more hydrophilic/water soluble ✓ carbohydrates are broken down/hydrolysed/digested by bacteria/micro-organisms ✓ plastic becomes more accessible to bacteria as holes/channels are created in it ✓ **«**presence of**»** carbohydrate weakens intermolecular/London/dispersion forces between polymer chains in the plastic ✓	*Accept "starch" for "carbohydrate" throughout.* *Do **not** accept carbohydrates are broken down/hydrolyzed.*	**2 max**

Question			Answers	Notes	Total
8.	a		 *Name:* amide/amido/carboxamide ✓	*Accept "peptide bond/linkage".*	**2**
8.	b		 *Phe:* must be on the origin ✓ *Asp:* any position on the left/anode/+ side ✓		**2**

Question			Answers	Notes	Total
9.	**a**		coconut oil has higher content of lauric/short-chain «saturated» fatty acids ***OR*** cocoa butter has higher content of stearic/palmitic/longer chain «saturated» fatty acids ✓ longer chain fatty acids have greater surface area/larger electron cloud ✓ stronger London/dispersion/instantaneous dipole-induced dipole forces «between triglycerides of longer chain saturated fatty acids» ✓	*Do **not** accept arguments that relate to the melting points of saturated and unsaturated fats.*	**3**
9.	**b**		 correct products ✓ correctly balanced ✓		**2**

(continued…)

(Question 9 continued)

Question			Answers	Notes	Total
9.	**c**		*Any two of:* **«**increased risk of**»** coronary/heart disease ✓ **«**increased risk of**»** stroke ✓ **«**increased risk of**»** atherosclerosis ✓ **«**increased risk of type-2**»** diabetes ✓ increase in LDL cholesterol ✓ decrease in HDL cholesterol ✓ **«**increased risk of**»** obesity ✓		**2 max**

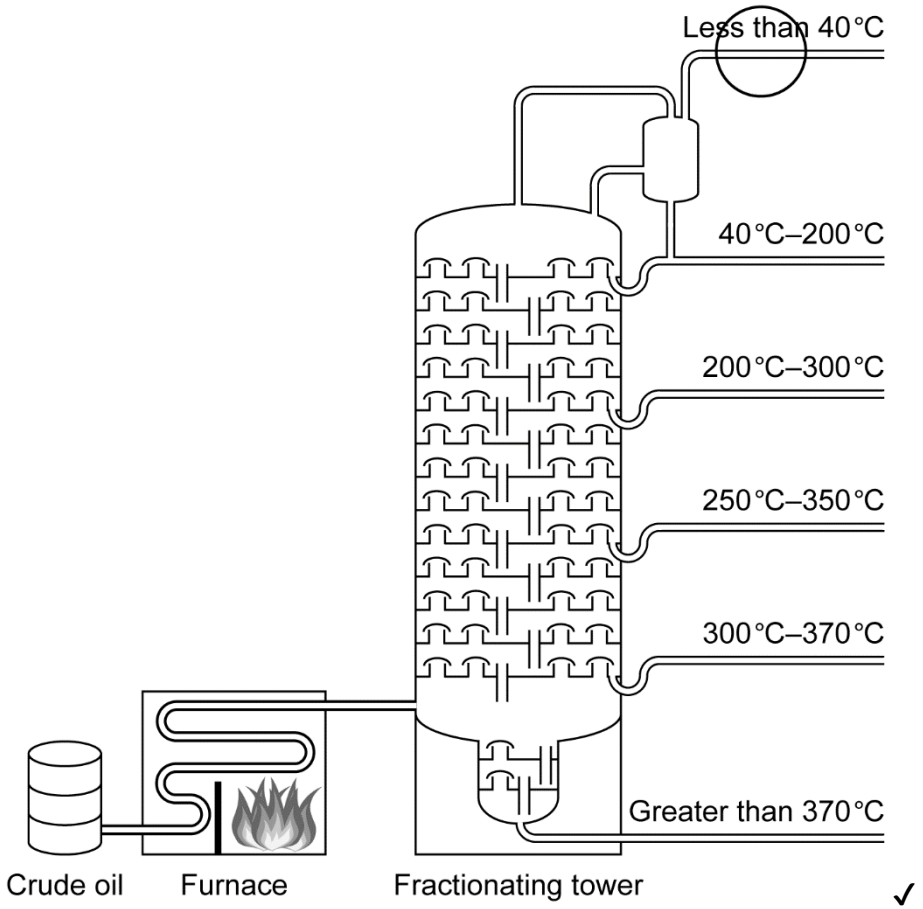
Question			Answers	Notes	Total
10.			*ascorbic acid:* many hydroxyl/OH groups ***AND*** *retinol:* few/one hydroxyl/OH group ***OR*** *ascorbic acid:* many hydroxyl/OH groups ***AND*** *retinol:* long hydrocarbon chain ✓ *ascorbic acid:* **«**many**»** H-bond with water ***OR*** *retinol:* cannot **«**sufficiently**»** H-bond with water ✓	*Do **not** accept "OH^-/hydroxide".*	**2**

Option C — Energy

Question			Answers	Notes	Total
11.	**a**		«$\frac{891\,\text{kJ mol}^{-1}}{16.05\,\text{g mol}^{-1}} = 55.5\,\text{kJ g}^{-1}$ =» 55.5 «MJ kg^{-1}» ✓		**1**
11.	**b**	**i**	«55.5 MJ × 58 % =» 32.2 «MJ» ✓		**1**
11.	**b**	**ii**	*Reason for higher efficiency:* no heat/energy loss in producing steam ***OR*** no need to convert chemical energy of the fuel into heat and then heat into mechanical energy ***OR*** direct conversion of «gravitational» potential energy to mechanical energy ✓ *Reason for decreased use:* limited supply of available hydroelectric sites ***OR*** rapid growth of electrical supply in countries with little hydroelectric potential ***OR*** not building «new hydroelectric» dams because of environmental concerns ✓	*Accept "less energy lost as heat" but do **not** accept "no energy lost".* *Accept "new/alternative/solar/wind power sources «have taken over some of the demand»".* *Accept "lower output from existing stations due to limited water supplies".*	**2**

(continued…)

(Question 11 continued)

Question			Answers	Notes	Total
11.	**c**	**i**	 ✓ [Source: Image used with kind permission of science-resources.co.uk]		**1**
11.	**c**	**ii**	gasoline > diesel > lubricating motor oil > asphalt ✓	*Accept products written in this order whether separated by >, comma, or nothing.*	**1**

(continued…)

(Question 11 continued)

Question			Answers	Notes	Total
11.	**d**	**i**	methane is tetrahedral ***OR*** methane has zero dipole moment/is non-polar/bond polarities cancel ✓ *Any two of:* IR absorption can result in increased vibrations/bending/stretching ✓ only modes that cause change in dipole absorb IR ✓ for methane this is asymmetric bending/stretching ✓		**3 max**
11.	**d**	**ii**	methane is less abundant ***AND*** has a greater effect «per mol» ✓		**1**

Question			Answers	Notes	Total
12.	**a**	**i**	$^{235}U + {}^{1}n \rightarrow {}^{144}Ba + {}^{89}Kr + 3\ {}^{1}n$ ✓		**1**
12.	**a**	**ii**	greater binding energy per nucleon in products than reactant ✓	*Accept "mass of products less than reactants"* ***OR*** *"mass converted to energy/$E = mc^2$".*	**1**
12.	**b**		mass/amount/quantity required so that «on average» each fission/reaction results in a further fission/reaction ✓ at least one of the «3» neutrons produced must cause another reaction ✓	*Accept "minimum mass of fuel needed for the reaction to be self-sustaining".*	**2**
12.	**c**		«6.25 % = 4 half-lives, so $4 \times 3.15 =$» 12.6 «min» ✓		**1**

Question			Answers	Notes	Total
13.	a		increased ***AND*** fuels can be compressed more «before ignition» ✓	*Accept "engines can be designed with higher compression ratio"* ***OR*** *"less chance of pre-ignition/auto-ignition/knocking occurring".*	1
13.	b		***Alternative 1*** $C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$ / 1 mol ethanol produces 2 mol CO_2 ***OR*** $C_8H_{18}(l) + 12.5O_2(g) \rightarrow 8CO_2(g) + 9H_2O(l)$ / 1 mol octane produces 8 mol CO_2 ✓ For 1 g of fuel: « $\frac{1\,g}{46\,g\,mol^{-1}} \times 2\,mol\ CO_2(g)$ =» 0.04 «mol $CO_2(g)$» from ethanol ✓ « $\frac{1\,g}{114\,g\,mol^{-1}} \times 8\,mol\ CO_2(g)$ =» 0.07 «mol $CO_2(g)$» from octane ✓ ***Alternative 2*** ratio of C in ethanol:octane is 2:8, so ratio in carbon dioxide produced per mole will be 1:4 ✓ ratio amount of fuel in 1 g = $\frac{1}{46}:\frac{1}{114}$ = 2.5:1 ✓ 4 > 2.5 so octane produces more carbon dioxide ***OR*** ratio of amount of carbon dioxide = 2.5:4 = 1:1.61 so octane produces more «for combustion of same mass» ✓		3

(continued…)

(Question 13 continued)

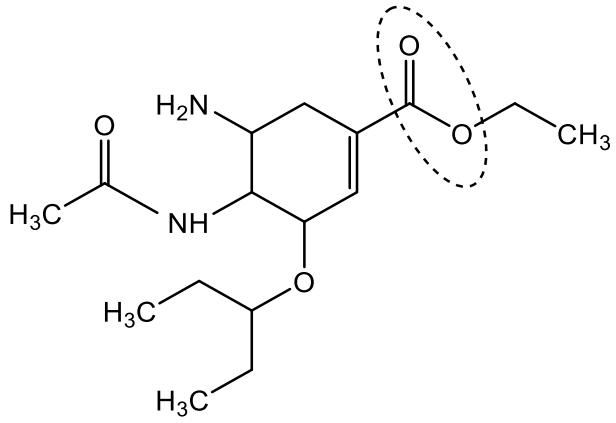
Question			Answers	Notes	Total
13.	**c**		use of «farm» land **«**for production**»** ***OR*** deforestation **«**for crop production for fuel**»** ***OR*** can release more NO_x **«**than normal fuel on combustion**»** ✓	*Ignore any reference to cost.*	**1**

Option D — Medicinal chemistry

Question			Answers	Notes	Total
14.			*Name:* hydroxyl ✓ *Absorption band:* 3200–3600 «cm^{-1}» ✓	*Accept "phenol" **OR** "alcohol" but **not** "hydroxide".*	**2**

Question			Answers	Notes	Total
15.	**a**		«four-membered» beta-lactam ring ✓	*Accept a diagram showing a structural representation of the beta-lactam ring.*	**1**
15.	**b**	**i**	produce penicillinase/enzyme that deactivates penicillin ✓		**1**
15.	**b**	**ii**	side-chain changed «preserving beta-lactam ring» ✓	*Accept "R group changed".*	**1**

Question			Answers	Notes	Total
16.	**a**	**i**	$CaCO_3(s) + 2HCl(aq) \rightarrow CO_2(g) + CaCl_2(aq) + H_2O(l)$ ✓	*Accept balanced ionic equations involving "H^+" or "H_3O^+".* *Do **not** accept "H_2CO_3".*	**1**
16.	**a**	**ii**	$n\ CaCO_3 =$ **«** $\frac{1.00\,g}{100.09\,g\,mol^{-1}}$ **=»** 0.00999 **«**mol**»** ✓ volume CO_2 = **«**0.00999 mol × 22.7 $dm^3\,mol^{-1}$ = **»** 0.227 **«**dm^3**»** ✓	*Accept 0.224 «dm^3» if 22.4 $dm^3\,mol^{-1}$ is used as molar volume.* *Award **[2]** for correct answer.*	**2**
16.	**b**		*Omeprazole:* inhibits enzyme/**«**gastric**»** proton pump **«**which secretes H^+ ions into gastric juice**»** ***OR*** inhibits the H^+/K^+-ATPase system ✓ *Ranitidine:* inhibits/blocks H2/histamine receptors **«**in cells of stomach lining**»** ***OR*** prevents histamine binding to H2/histamine receptors **«**and triggering acid secretion**»** ✓	*Accept "H2-receptor antagonist" for M2.*	**2**

Question			Answers	Notes	Total
17.	a	i	 ✓	*Accept circles that include the alkyl side chain.*	**1**
17.	a	ii	more soluble **«**in water**»** ✓		**1**
17.	b		viruses undergo **«**rapid**»** mutation ✓ mutation causes a change in viral protein ***OR*** drug to no longer binds to virus ✓	*Accept "rapid reproduction **«**allows resistant viruses to multiply**»**".*	**2**

Question			Answers	Notes	Total
18.	a		«temporarily» bond/bind to «opioid» receptors in the brain/CNS ✓ block the transmission of pain impulses ✓		2
18.	b		«codeine crosses blood–brain barrier more easily» morphine has more hydroxyl/OH «groups than codeine» ✓ codeine/ether group is less polar ***OR*** hydroxyl/OH «groups in morphine» H-bond to water ✓	*Award **[1 max]** if no statement or an incorrect statement about the blood–brain barrier.*	2

Question			Answers	Notes	Total
19.	a		small/low amounts of radiation ***AND*** for a short time ✓	*Accept "weakly ionizing radiation" instead of "small amounts of radiation".* *Accept "short half-lives" instead of "for a short time".*	1
19.	b		stored in shielded containers until radiation drops «to a safe level» ✓		1